WHAT IS CLAIMED IS:

1. An optical amplification module for collectively amplifying signal light having multiplexed a plurality of channels in a signal wavelength band including a wavelength region having a wavelength of 1610 nm or longer, said optical amplification module comprising:

a Bi type optical waveguide, comprised of Bi oxide type host glass, including an optical waveguide region doped with Er element, for propagating the signal light; and

a pumping light supply system for supplying the optical waveguide region with pumping light so as to generate a population inversion within the optical waveguide region of said Bi type optical waveguide.

2. An optical amplification module according to claim 1, wherein the optical waveguide region doped with Er element is further doped with B element.

3. An optical amplification module according to claim 1, further comprising a control unit for adjusting an optical power of the pumping light supplied from said pumping light supply system to said Bi type optical waveguide so as to yield a relative gain non-uniformity of less than 25% in a net gain spectrum of said Bi type optical waveguide at a predetermined operating temperature within an operating temperature range of said optical amplification module.

4. An optical amplification module according to claim 3, wherein the relative gain non-uniformity is less than

19%.

5. An optical amplification module according to claim 1, further comprising a control unit for adjusting an optical power of the pumping light supplied from said pumping light supply system to said Bi type optical waveguide so as to yield a relative gain non-uniformity of less than 25% in a net gain spectrum of said Bi type optical waveguide within a whole operating temperature range of said optical amplification module.

6. An optical amplification module according to claim 5, wherein the relative gain non-uniformity is less than 19%.

7. An optical amplification module according to claim 1, further comprising a control unit for adjusting an optical power of the pumping light supplied from said pumping light supply system to said Bi type optical waveguide so as to yield a relative gain non-uniformity of less than 25% in a net gain spectrum of said Bi type optical waveguide in a wavelength bandwidth exceeding 37 nm within a whole operating temperature range of said optical amplification module.

8. An optical amplification module according to claim 7, wherein the wavelength bandwidth exceeds 50 nm.

9. An optical amplification module according to claim 1, further comprising a control unit for adjusting an optical power of the pumping light supplied from said pumping light

supply system to said Bi type optical waveguide so as to yield a relative gain non-uniformity of less than 19% in a net gain spectrum of said Bi type optical waveguide in a wavelength bandwidth exceeding 37 nm within a whole operating temperature range of said optical amplification module.

10. An optical amplification module according to claim 9, wherein the wavelength bandwidth exceeds 50 nm.

11. An optical amplification module according to claim 1, further comprising a temperature detecting device for detecting a temperature of said Bi type optical waveguide or nearby.

12. An optical amplification module according to claim 1, further comprising a temperature adjusting device for adjusting a temperature of said Bi type optical waveguide or nearby.

13. An optical amplification apparatus comprising:

an optical amplification module according to claim 12; and

a control unit for changing the temperature of said Bi type optical waveguide or nearby in said optical amplification module by ΔT (K) according to an actual gain change amount ΔG (dB) in said optical amplification module.

14. An optical amplification apparatus according to claim 13, wherein said control unit regulates the ΔT (K) so as to satisfy the following relationship:

$$\begin{aligned}&(\Delta T \cdot G_{\min}) \times 0.0036 - 1.2\\ &\quad \le \Delta G \le\\ &(\Delta T \cdot G_{\min}) \times 0.0036 + 1.2\end{aligned}$$

where G_{min} (dB) is the minimum value of actual gain within the signal wavelength band at 25°C in said Bi type optical waveguide alone.

15. An optical amplification apparatus according to claim 13, wherein said control unit comprises a memory having stored therein data of ΔG (dB) and ΔT (K) actually measured during an actual operation of said optical amplification apparatus.

16. An optical amplification apparatus comprising:

an optical amplification module according to claim 12; and

a control unit for changing the temperature of said Bi type optical waveguide or nearby according to a detected gain tilt.

17. An optical amplification apparatus comprising:

an optical amplification module according to claim 12;

a variable attenuator, disposed on a transmission path of the signal light, having a variable loss characteristic with respect to the signal light; and

a control unit for ordering said Bi type optical waveguide of said optical amplification module to be heated and cooled when a detected gain tilt in said optical

amplification module is positive and negative, respectively.

18. An optical amplification module according to claim 1, further comprising a light-losing component, disposed on a transmission path of the signal light, having a variable loss characteristic with respect to the signal light.

19. An optical amplification module according to claim 18, wherein said light-losing component includes a variable optical attenuator.

20. An optical amplification apparatus comprising:

an optical amplification module according to claim 19; and

a control unit for determining an optical attenuation amount ΔA (dB) in said variable optical attenuator in said optical amplification module according to a detected temperature change ΔT (K) of said Bi type optical waveguide or nearby in said optical amplification module.

21. An optical amplification apparatus according to claim 13, further comprising a variable attenuator, disposed on a transmission path of the signal light, having a variable loss characteristic with respect to the signal light;

wherein said control unit regulates said variable attenuator such that an optical attenuation amount ΔA (dB) in said variable attenuator is in proportion to the detected temperature change ΔT (K).

22. An optical amplification apparatus according to claim 13, further comprising a variable attenuator, disposed on a transmission path of the signal light, having a variable loss characteristic with respect to the signal light;

wherein said control unit regulates said variable attenuator according to the temperature change ΔT (K) such that the optical attenuation amount ΔA (dB) in said variable optical attenuator satisfies the following relationship:

$$\begin{aligned} &-0.0036 \cdot G_{\min} \cdot \Delta T - 1.2 \\ &\leq \Delta A \leq \\ &-0.0036 \cdot G_{\min} \cdot \Delta T + 1.2 \end{aligned}$$

where G_{min} (dB) is the minimum value of actual gain within the signal wavelength band at 25°C in said Bi type optical waveguide alone in said optical amplification module.

23. An optical amplification apparatus according to claim 20, wherein said control unit regulates said variable optical attenuator according to the actual gain change amount ΔG (dB) in said optical amplification module and the temperature change ΔT (K) such that the optical attenuation amount ΔA (dB) in said variable optical attenuator satisfies the following relationship:

$$\begin{aligned} &-0.0036 \cdot G_{\min} \cdot \Delta T - \Delta G - 1.2 \\ &\leq \Delta A \leq \\ &-0.0036 \cdot G_{\min} \cdot \Delta T - \Delta G + 1.2 \end{aligned}$$

where G_{min} (dB) is the minimum value of actual gain within the signal wavelength band at 25°C in said Bi type optical

waveguide alone in said optical amplification module.

24. An optical amplification apparatus according to claim 20, wherein said control unit comprises a memory having stored therein data of actual gain change amount ΔG (dB) and temperature change ΔT (K) in said optical amplification module actually measured during an actual operation of said optical amplification apparatus.

25. An optical amplification apparatus according to claim 20, wherein said control unit comprises a memory having stored therein data of actual gain change amount ΔG (dB) and temperature change ΔT (K) in said optical amplification module and optical attenuation amount ΔA (dB) in said variable optical attenuator actually measured during an actual operation of said optical amplification apparatus.

26. An optical amplification apparatus comprising:

an optical amplification module according to claim 19; and

a control unit for changing an optical attenuation amount ΔA (dB) of said variable optical attenuator according to a detected gain tilt in said optical amplification module.

27. An optical amplification apparatus comprising:

an optical amplification module according to claim 12 including a variable attenuator, disposed on a transmission path of the signal light, having a variable loss characteristic with respect to the signal light; and

a control unit for ordering said Bi type optical

waveguide of said optical amplification module to increase and decrease an optical attenuation amount ΔA (dB) of said variable optical attenuator when a detected gain tilt in the optical amplification module is positive and negative, respectively.

28. An optical amplification module according to claim 1, satisfying the following relationship:

$$\alpha_B \leq 0.021\alpha$$

where α_B (dB/m) is the background loss of said Bi type optical waveguide, and α (dB/m) is the absorption peak due to Er.

29. An optical amplification module according to claim 1, satisfying the following relationship:

$$\alpha_B \leq 0.015\alpha$$

where α_B (dB/m) is the background loss of said Bi type optical waveguide, and α (dB/m) is the absorption peak due to Er.

30. An optical amplification module according to claim 1, wherein said Bi type optical waveguide includes an optical fiber.

31. An optical amplification module according to claim 1, wherein said pumping light supply system includes a light source having a center output wavelength falling within the range from 1453 nm to 1473 nm at the highest output.

32. An optical amplification module according to claim 1, wherein said pumping light supply system includes a light source always having a center output wavelength falling within the range from 1453 nm to 1473 nm.

33. An optical amplification module according to claim 1, wherein said pumping light supply system comprises:

a semiconductor light-emitting device including a light-reflecting surface and a light-emitting surface opposing the light-reflecting surface; and

a grating for reflecting a part of light having a specific wavelength in light emitted from the light-emitting surface of said semiconductor light-emitting device, and making thus emitted light incident on the inside of said semiconductor light-emitting device from the light-emitting surface.

34. An optical amplification module according to claim 33, wherein said grating includes an optical fiber grating formed on an optical fiber.

35. An optical amplification module according to claim 1, further comprising a silica-based optical waveguide comprised of silica-based host glass including an optical waveguide region which is doped with Er element and through which the signal light propagates.

36. An optical amplification module according to claim 35, wherein said silica-based optical waveguide is disposed on a transmission path of the signal light so as to be located on the upstream side of said Bi type optical waveguide as seen in a traveling direction of the signal light.

37. An optical amplification module according to

claim 35, wherein said silica-based optical waveguide is disposed on a transmission path of the signal light so as to be located on the downstream side of said Bi type optical waveguide as seen in a traveling direction of the signal light.

38. An optical amplification module according to claim 35, wherein the optical waveguide region of said silica-based optical waveguide is codoped with P element and at least one of Al and La elements.

39. An optical amplification apparatus comprising an optical amplification module according to claim 1, said optical amplification module amplifying signal light having multiplexed a plurality of channels included in L band.

40. An optical amplification apparatus according to claim 39, further comprising a Raman amplification optical fiber disposed on a transmission path of the signal light so as to be located on the upstream side of said Bi type optical waveguide as seen in a traveling direction of the signal light.

41. An optical amplification apparatus according to claim 40, wherein said Raman amplification optical fiber is supplied with at least one of pumping light near a wavelength of 1470 nm and pumping light having a wavelength of 1520 nm or more.

42. An optical communications system comprising the optical amplification apparatus according to claim 39, said

optical communications system transmitting signal light having multiplexed a plurality of channels included in L band, said optical amplification apparatus amplifying the signal light.

43. An optical communications system according to claim 42, further comprising a Raman amplification optical fiber disposed on a transmission path of the signal light so as to be located on the upstream side of said optical amplification apparatus as seen in a traveling direction of the signal light.

44. An optical communications system according to claim 43, wherein said Raman amplification optical fiber is supplied with at least one of pumping light near a wavelength of 1470 nm and pumping light having a wavelength of 1520 nm or more.